

Mechanical Properties of Polyester Reinforced with Powdered Shells of the Snail Composites

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ORIGINAL
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Abstract – *Composites of unsaturated polyester has been found to be useful virtually in all aspects of life. This project work was carried out to investigate the properties of particulate snail shell reinforced unsaturated polyester matrix composites. The snail shell particulate was calcinated, pulverized and sieved to -75 μ m. The composites were developed using predetermined varying filler content. For each of the developed composites, the mixture was missed thoroughly until homogenous paste was obtained and poured into the mould and was allowed to cure before removing from the mould. The developed composites were then characterized by flexural and wear tests. The result showed that significant results can be obtained within 5-20 wt% reinforcement addition since 25-30 wt% tends to give weak results in all. The result further proved that properties of the developed composites were highly enhanced compared to the unreinforced polyester material. The optimum properties were observed at 20% filler content.*

Keywords: Composite, Unsaturated Polyester, Snail Shell, Filler, flexural, wear

I. INTRODUCTION

Polymer matrix composite application has been widely used and very important in our modern world. In view of the unique properties that it has a stiffer, lighter and stronger compared with unreinforced or conventional metals, that widely used in aerospace structures, boat and automotive parts that will be further discussed in this paper. It is as a result of the combination of properties which are imbedded into these materials. Part of the properties of polymer matrix composites among others are high modulus, specific

strength, corrosion resistance, good fracture and fatigue properties [1]. The past few decades have seen outstanding advances in the use of composite materials in both mechanical and structural applications. There can be little doubt that, within engineering circles, composites have revolutionized traditional design concepts and made possible an unparalleled range of new and exciting possibilities as viable materials for construction.

The reinforcing fibers are the primary load carriers of material, with the matrix component transferring the load from fiber. Reinforcement of the matrix material may be achieved in a variety of ways. Reinforcement may also be in the form of particles. The matrix material is usually one of the many available engineering plastics/polymers. Selection of the optimal reinforcement form and material is dependent on the property requirements of the finished part.

In several years' composite materials, plastics and ceramics have been the reigning emerging materials. In developing countries, harvest season are often accompanied with residues that are of environmental menace and in some cases hazardous. Many of these materials as fillers. Research is proceeding to develop composites using various recycled waste [10]. Especially in developing composites using most environmentally friendly agro-waste as reinforcing fillers and thermosetting polymers as matrices. Recent investigation of polymer-based composite materials has opened new routes for polymer formulations and have allowed the manufacture of new products with optimal properties for special application. In most cases, these composites improve the product design and reduce the material and energy consumption.

Today, the growing environmental awareness throughout the world has triggered a paradigm shift from synthetic

fibers and their composites towards composites made from natural reinforcing constituents (natural fibers and natural particulate fillers) which are more environmentally friendly [7]. In the light of this, researchers have focused their attention on composites composed of natural or synthetic resins [9]. Reinforced with material particulate fillers and manufacturing of high-performance engineering materials from these renewable resources has also been pursued by researchers since renewable raw materials are environmentally sound and do not cause health problem [6]. Fillers having cellulose, hemi cellulose and lignin are being investigated for the suitability of replacing synthetic fibers [11]. The use of these natural fillers has been due to its economic advantage during processing, high specific strength, relatively low density and biodegradability, thereby reducing environmental pollution [2]. Commonly used particulate fillers include; talc, calcium carbonate, kaolin, silica and carbon black.

Polymers have numerous applications ranging from domestic articles to their use as matrix in composite applications. It is a light weight alternative to most metals. The utilization of natural fibers and fillers as reinforcement for composite materials based on thermoplastic and thermosetting polymers such as polypropylene and polyester is gaining ground in sustainable research area in the polymers world.

The major reasons for a huge growth in the area of polymeric composite materials are low weight, low price and minimization of environmental impact. Unsaturated polymer resins are versatile when it comes to properties especially because of its capability to cure at room temperature. In the study of the mechanical properties of rice- husk fiber reinforced polyester composite, result showed that the tensile and flexural strength of the composite increased when the fiber weight fraction increased [9].

When bagasse/sugar cane fiber was used to reinforced unsaturated polyester material in order to assess the viability of the composite material developed for engineering applications, results showed that the reinforcement enhanced the mechanical properties of the developed composite [8]. Egg shell particles have been used as reinforcement in polyester matrix and the results showed that the density and hardness values of the polyester/egg shell particulate composite increased steadily with increasing egg shell addition, flexural strength as well as impact energy, tensile and bending strength also increased

[4]. A ceramic composite was prepared by adding ceramic particles to unsaturated polyester resin, from the investigation, filling the unsaturated polyester resin by CaCO_3 and MgO filler particles led to an increased in the ultimate tensile strength [3].

II. EXPERIMENTAL

Materials and equipment

- Snail shell
- Polyester
- Methyl ethyl ketone peroxide
- Sieve shaker
- Cobalt naphthanate

Snail Shell Preparation and Calcination

Snail Shell was washed in flowing water to removed sand and dirt followed by sun drying for days before taken to Kiln Oven for Calcination where it was maintained at a temperature of 1000°C for 3 hours to remove other organic matter present in it. The calcined Snail shell was pulverized with high mechanized machine of ISO 895. The pulverized calcined snail shell was sieved with a sieve shaker to obtain less than $75\ \mu\text{m}$.

Preparation of unsaturated polyester composite:

Required materials were weighed out using an electronic weighing balance. The weight percentages of the constituents are shown in Table 3.1. In synthesizing the reinforced polyester composites, the mass of the polyester was varied with that of the reinforcement to give a total of 100 g. The filler is added into the polyester resin and stirred continuously with a glass rod for about 4 minutes until a uniform mixture was observed. Thereafter, 2.4 g of catalyst was added with the aid of disposable syringe and stirred for about two minutes, after which 1.2 g of accelerator was also added and stirred for about two minutes. The mixture was poured into a mould and allowed to cure. This procedure was repeated for other specimen as shown in Table 3.1 with changes in the weight percentages of the particulate filler. A control sample was produced without the addition of the particulate snail shell filler. After curing, the samples were removed from the mould.

Table 1. Formulation of filler/polyester composites

Specimen	Composition (g)	Composition (g)	Composition (g)	Composition (g)
	Particulate snail shell filler	Unsaturated polyester	Methyl ethyl ketone peroxide (catalyst)	Cobalt naphthanate (accelerator)
1	5	95	2.4	1.2
2	10	90	2.4	1.2
3	15	85	2.4	1.2
4	20	80	2.4	1.2
5	25	75	2.4	1.2
6	30	70	2.4	1.2
Control	0	100	2.4	1.2

The produced polyester matrix composite with different particle size for snail shell particles were made to undergo series of tests, which includes flexural and wear (abrasion).

Flexural test

Three points bending test was used to evaluate the flexural strength (F.S) of the samples. The test was done by placing the samples under a three- point bend fixture. The flexural test was carried according to ASTM D7264 at a cross- head speed of 20 mm/min, maintaining a span of 100 mm. it was carried at room temperature. Specimens were of 115 x 25 x 3 mm. It was conducted using Testometric Testing Machine at Obafemi Awolowo University, Ife.

Abrasion resistance test (wear)

This test was carried out at Federal University of Technology, Akure (Metallurgical and Materials Engineering Laboratory). The sample was secured to the instrument platform, which is a motor driven at a fixed speed. Two abrasive wheels are lowered onto the samples surface, and as the platform rotates, it turns the two wheels. This causes a rubber-wear action on the surface of the test piece and the resulting abrasion marks from a pattern of crossed arcs in a circular band that cover an area of 30 cm against all angles of weave or grain. A vacuum system removes debris testing. The wear procedure follows the standard CS-10 Calibrase or H-18 Calibrade.

III. RESULTS AND DISCUSSIONS

Table 2. Flexural Strength Test Result

Samples (%)	Flexural strength at peak (MPa)	Flexural strength at break (MPa)	Energy at yield (J)	Bending modulus (MPa)
5	13.10	0.87	0.14	485.81
10	10.00	0.40	0.06	355.82
15	15.31	0.87	0.11	649.88
20	13.81	1.11	0.09	710.36
25	9.02	1.95	0.07	394.74
30	11.28	0.38	0.08	541.30
Control	9.10	0.71	0.07	449.46

Table 3. Abrasion Resistance (Wear) Test Result

Samples (%)	Initial weight (g)	Final weight (g)	Weight difference (g)
5	37.32	37.24	0.08
10	38.18	38.11	0.07
15	30.69	30.56	0.13
20	30.02	29.89	0.13
25	32.82	32.71	0.11
30	32.02	31.89	0.13
Control	25.50	24.33	1.17

IV. DISCUSSION

Flexural test discussions



Figure 1. Chart of Flexural strength at peak against filler content and the control

Figure 4.1 show the response of the materials to flexural strength at peak. From the results, it was observed that the snail shell reinforced polyester composites had its maximum flexural strength at peak at 15 wt% filler content with a value of 15.31 MPa followed by 5 wt% with a value of 13.40 MPa compare to control sample which has a value of 10.00 MPa. The result showed that better enhancement was achieved in almost all the wt% used except at 25 wt%.

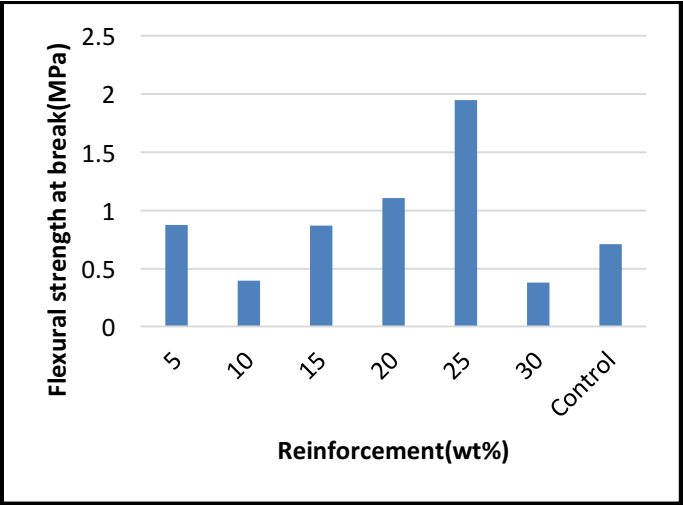


Figure 2. Chart of flexural strength at break against filler content and the control

From Figure 4.2, the increase in particles reinforcement concentration resulted in increase in the flexural strength at break of the composites except that of 5wt% and that of 30 wt% which may due to production error. The highest flexural strength at break was achieved at 25 wt% with a value of 1.95 MPa followed by that of 20 wt% with a value of 1.11MPa compare to other reinforcements and the control sample which has 0.71 MPa. As the filler content increases, the flexural strength at break also increases.

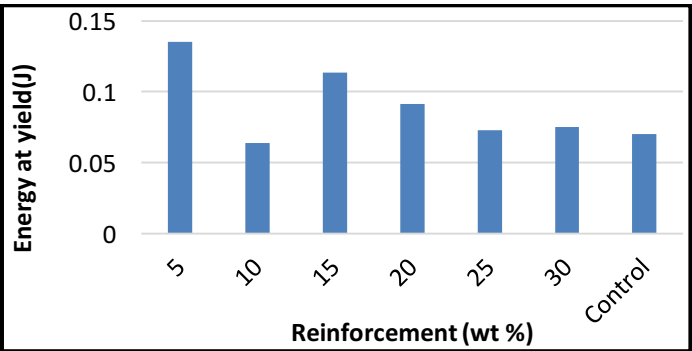


Figure 3. Chart of energy at yield against filler content and the control

Figure 4.3 shows the results of the energy at yield. The highest energy at yield was achieved at 5 wt% reinforcement with a value of 0.14 J followed by that of 15 wt% with a value of 0.11J compare to other samples and that of control sample which has 0.07 J. It is observed that apart from 10 wt% which may due to some errors engaged during production, others decreased as the filler concentrations increases. This may also due to good wetting and bonding between the matrix and the reinforcement.



Figure 4. Chart of flexural modulus against filler content and the control

Figure 4.4 shows the flexural modulus of the composites at different filler contents. The flexural modulus did not follow any regular form but has highest value at 20 wt% with a value of 710.36 MPa and followed by that of 15 wt% with a value of 649.88 MPa compare to other reinforcements and that of the control sample which has the value of 449.46 MPa.

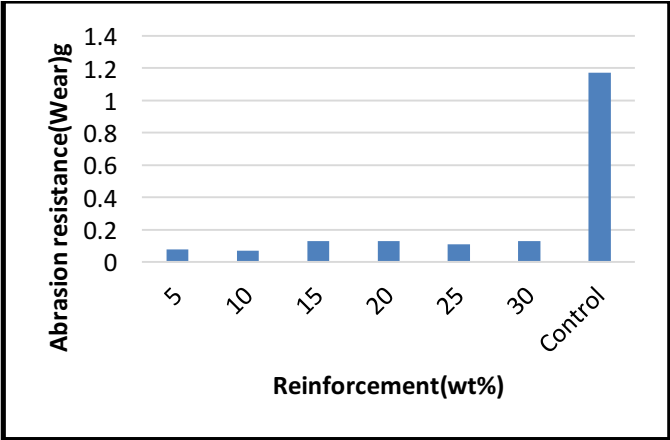


Figure 5. Chart of abrasion resistance (wear) against filler content and the control

The wearing of the composites has the lowest value of abrasion resistance at 10 wt% with value of 0.07 g has the best abrasion resistance as shown in Figure 4.9, which means, 5 wt% is the best material that will not wear off on

time followed by 10 wt% with a value of 0.08g, while the control has 1.17 g. From the results, it is observed that the lesser the filler concentration, the best the abrasion (wear) resistance.

V. CONCLUSION

It was observed that the mechanical properties of polyesters can be greatly improved by reinforcing it with particulate snail shell filler. The materials behavior to flexural test revealed that composites samples developed from 15-20 wt% reinforcements gave the best results, respectively while from abrasion resistance(wear) test results, it is observed that composite sample with 5 wt% and 10wt% it is obvious that unsaturated polyester/particulate snail shell composite with 5 wt% reinforcement has the best abrasive resistance. The implication is that snail shell reinforcement of 5wt% will have failure resistance like brake pads.

The result revealed that better results can be obtained within 5-20 wt% reinforcement addition since 25-30 wt% tends to give weak results in all.

Snail shell/polyester composite can be used in place of pure polyester depending on the filler content and user area of interest like aerospace, maritime, car parts etc.

VI. DECLARATION

All authors have disclosed no conflicts of interest and the project was self funded.

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